U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1623

THE GIPSY MOTH AND THE BROWN-TAIL MOTH

THE GIPSY MOTH and the brown-tail moth are two very destructive enemies of tree foliage which have gained entry into this country from Europe. The gipsy moth has spread over a large part of New England, and isolated colonies have been found in New York State east of the Hudson River, on Long Island, and in New Jersey. The brown-tail moth has become established in many localities, embracing about one-third of the area of the New England States.

Substantial progress has been made in exterminating the gipsy moth in New Jersey, and many isolated infestations have been cleaned up in other States.

During the last 10 years the brown-tail moth has been far less abundant than was previously the case, except in certain sections in the eastern part of the infested territory. The decrease has been due to such factors as heavy mortality during the winter, increase in the abundance of imported parasites, a fungous disease that attacks the larvae, and field control work including spraying operations.

The States and the Federal Government (the latter through research conducted by the Bureau of Entomology and quarantine and control work conducted by the Plant Quarantine and Control Administration) are actively engaged in destroying these insects by the use of appropriate measures. The Federal Government is chiefly concerned in preventing their spread, while the States aim to reduce the infestations and prevent the defoliation of valuable trees in woodlands, orchards, and parks.

The methods which have been found effective in destroying the insects, together with a brief statement of the progress that has been made, are set forth in this bulletin.

This bulletin is a revision of and supersedes Farmers' Bulletin 1335, Controlling the Gipsy Moth and the Brown-Tail Moth.

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THE GIPSY MOTH AND THE BROWN-TAIL MOTH

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THE GIPSY MOTH

INTRODUCTION AND SPREAD

IN 1869 a number of egg clusters of the gipsy moth (*Porthetria dispar* L.) were brought from France to Medford, Mass., by a French mathematician and astronomer, who seemed to have had a fanciful idea that he could cross this insect with silkworm moths and thus develop a hardy race of silk-producing insects. In the course of his rearing experiments some of the eggs were accidentally lost or some of the caterpillars escaped, and he made at that time public acknowledgment of this fact, evidently somewhat appreciating the danger.

It is clear now that the insect increased slowly and after 10 years seemed to have been noticed by local residents but was believed to be some native caterpillar. It was not until some 20 years after the introduction, namely, in the summer of 1889, that this insect became so abundant and destructive as to bring it into general public notice. At that time fruit and shade trees in the immediate region were completely defoliated and the caterpillars swarming into the houses became a very grave nuisance. This situation was so serious that the State of Massachusetts appropriated funds and delegated to the State department of agriculture the task of exterminating this pest.

The area that was found to be infested covered about 359 square miles and the trees in many towns surrounding Boston were com-

pletely defoliated each season for a number of years. As the work continued, more effective methods of treatment were adopted and better results were obtained; consequently, during the summers of 1898 and 1899 little defoliation could be found in the entire area and few specimens of the moth were located throughout the entire residential sections of the infested district. Careful examination indicated that the insect had been exterminated in some of the towns around the outside border of the originally infested district. In February, 1900, the work was discontinued by the general court because of the popular belief that the danger had passed, in spite of the advice of experts that the insect had not been stamped out.

Within the next five years the insect increased enormously. Many of the towns and cities in the old infested district were overrun with caterpillars which completely defoliated the trees in many of the residential sections and thousands of acres of woodland were stripped of leaves during the summer. The situation became so serious and intolerable that in 1905 control work was resumed by the State of Massachusetts. In the meantime the insect had spread far beyond the original limits of infestation, over 2,224 square miles being involved in Massachusetts as well as a considerable number of isolated areas in Maine, New Hampshire, and Rhode Island.

In 1906 an appropriation was made by Congress and the Secretary of Agriculture was authorized to take all possible measures, in cooperation with the States concerned, to prevent the spread of this pest. The insect had increased to such enormous numbers and had spread so rapidly that the utmost efforts of the Federal and State forces were only able to apply relief measures in the badly infested residential sections and partially retard the continued spread of the pest. Efforts were made to prevent the shipment of the insect to uninfested localities by inspecting products that were likely to carry the insect. This phase of the work was greatly strengthened as a result of the enactment of the plant quarantine law by Congress on August 20, 1912.[1] Since October of that year shipments from the infested district have been regulated by Federal quarantine.

On account of the serious situation that was resulting from the continued spread and increasing damage caused by this insect, efforts were constantly being made to develop improved means of control. The process of manufacturing lead arsenate, which was first made and used in the gipsy-moth work in 1893, was perfected so that the cost of production was reduced and the product could be more effectively applied. Spraying machinery and equipment were developed to a high point of efficiency. Advantage was taken of the results of experimental work in carrying on the field operations, and the details of field management were constantly improved in order that the greatest possible volume of effective work could be done with the funds available.

This pest is distributed by natural means, principally by the newly hatched caterpillars being blown by strong winds when accompanied

[1] This act created the Federal Horticultural Board and gave authority for the establishment of Federal quarantines to prevent the spread of dangerous introduced insect pests and plant diseases. The act making appropriations for the Department of Agriculture for the fiscal year ended June 30, 1929, transferred the functions of this board, together with insect-control activities, to the Plant Quarantine and Control Administration.

by high temperatures in the spring. Under favorable conditions such caterpillars may drift a distance of 20 miles.

In spite of the efforts that were made by the Federal Government and all the States concerned, the insect continued to spread. By 1914 it had covered the southern half of New Hampshire and extended as far east as Bangor, Me. On the west it had crossed the Connecticut River in Vermont and Massachusetts. Rhode Island and many towns in eastern Connecticut were found to be infested.

During the war period conditions were most unfavorable for preventing spread. The loss of efficient personnel and constant turnover of men, together with extraordinary increase in costs, made progress difficult. During this period weather conditions were especially favorable for spread toward the west. By the fall of 1922, colonies were found in many towns in Vermont and west of the Connecticut River in Massachusetts and Connecticut, and an infestation was located in New York State adjoining the Massachusetts State line. Every indication pointed to the continued spread of the insect unless more intensive work could be done.

As a result of this serious situation a conference was held in the office of the commissioner of farms and markets in Albany, December 26, 1922, which was attended by representatives from all the infested States, the Dominion of Canada, and the United States Department of Agriculture.[2] The conference considered the entire subject of the prevention of spread of the gipsy moth and its control, and adopted a resolution urging that sufficient funds be obtained by the States interested and the Federal Government, for the purpose of continuing and strengthening present control methods in the infested area, to do necessary scouting for the discovery and destruction of border infestations, to determine the location of the most practical place for a control zone, to take necessary steps to make control therein effective, and for the destruction of all infestations in and west of said zone.

In order to carry out this project legislation was passed by the State of New York in April, 1923, carrying an appropriation of $150,000 to be administered by the department of conservation of that State. Federal funds were also provided for the fiscal year beginning July 1, 1923, in order to bring about effective cooperation.

The plan finally adopted, in cooperation with the New York Department of Conservation, was to locate a zone east of the Hudson River where clean-up operations would be centered in order to prevent westward spread of this pest. (Fig. 1.) The territory east of this zone was to be treated by the States concerned as far as their funds would permit, and their work was to be supplemented by liberation of imported parasites and other natural enemies of the insect by the Bureau of Entomology. Work in the New York portion of the area was to be financed by the State with such assistance as could be given by the bureau after covering the eastern part of the zone. This zone embraced an area of over 8,000 square miles extending from Long Island Sound east of the Hudson River (excluding

[2] THE GIPSY MOTH, AN IMMINENT MENACE TO THE FOREST AND SHADE TREES OF THE STATE OF NEW YORK. New York State Dept. of Farms and Markets, Agr. Bul. 148, 58 p., illus. 1922.

Westchester County, N. Y.) to the Canadian border, a distance of over 250 miles, and ranging in width from 25 to 30 miles.

While much of the extremely rugged country in the Adirondack and Green Mountains was avoided in northern New York and in Vermont, as well as the Catskills and some of the rougher country west of the Connecticut River in Connecticut, there are areas, embracing the Berkshire Hills in western Massachusetts and some of the

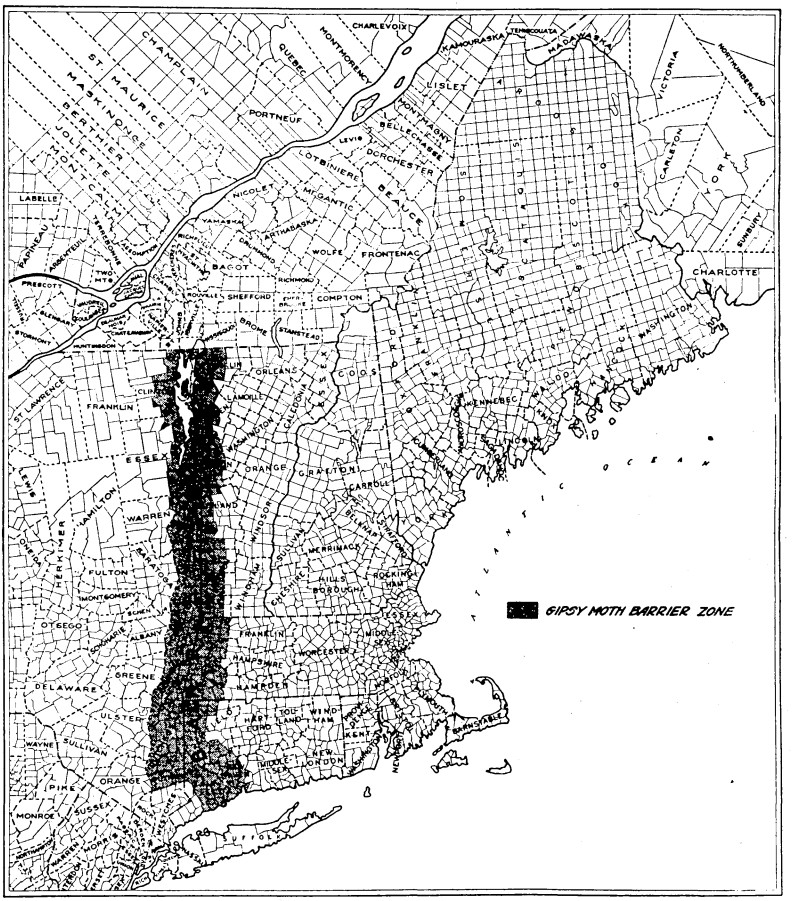

FIGURE 1.—Barrier zone in New England and New York

territory directly south and southwest of them in Connecticut and New York, where the terrain is extremely difficult.

In 1924, owing to the number of infestations found in Massachusetts and Vermont, and a vigorous colony that was located at Henrysburg, Quebec, by the inspection force of the Dominion entomologists of Canada, the quarantine line was moved westward to embrace the whole of the State of Vermont and additional towns in northwestern Connecticut. A foreign quarantine regulating the movement of Christmas trees was made effective covering the southern tier of towns in the Province of Quebec. (Fig. 2.) Since that time, owing to the effectiveness of the clean-up work in the barrier zone, sup-

plemented by a limited amount of scouting work carried on west of the zone as a precautionary measure, it has been possible to revise the area under quarantine and eliminate the area included in the zone. The Canadian quarantine was withdrawn July 1, 1928. (Fig. 3.)

The danger of reinfestation of the barrier zone depends to a very large extent on the density of infestation east of the zone. The

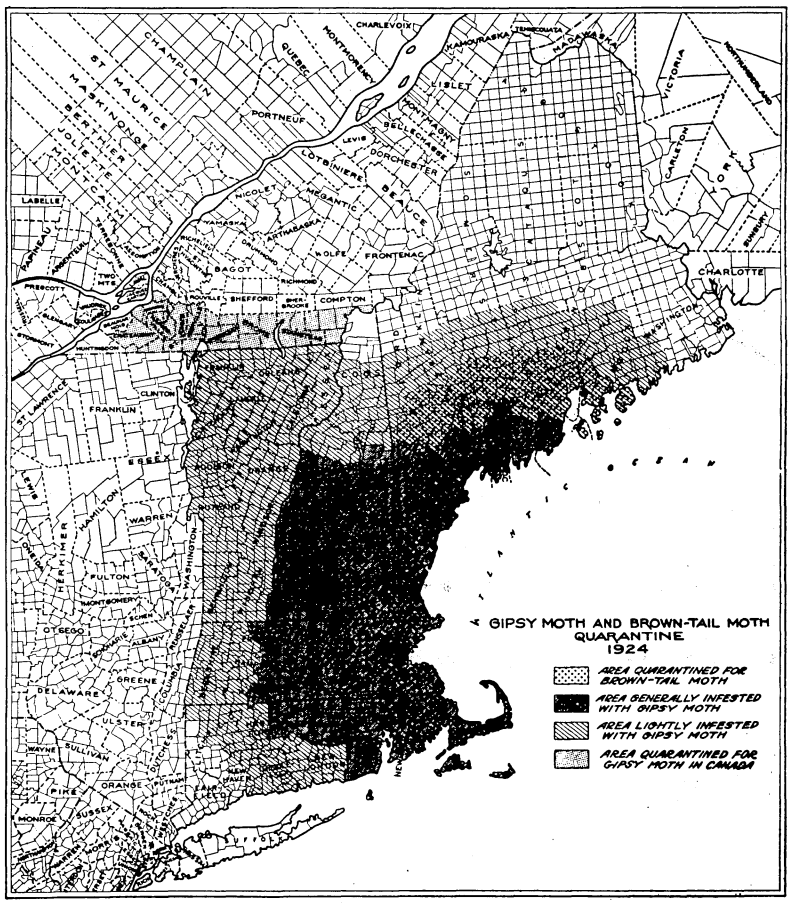

FIGURE 2.—Quarantined areas, 1924

following tabulation indicates the acreage defoliated by the gipsy moth east of the zone from 1924 to 1929, inclusive:

Acreage defoliated by the gipsy moth, 1924 to 1929, inclusive

Year	Acres	Year	Acres
1924	825	1927	140,920
1925	48,560	1928	262,514
1926	80,822	1929	551,133

It will be noted that defoliation has been increasing rapidly in the area east of the barrier zone, and during 1928 and 1929 the insect

was sufficiently abundant to cause some defoliation between the Connecticut River and the zone area. During the period covered by the tabulation, parasites and natural enemies of the gipsy moth have been scarce in most of the infested area, but in the summer of 1929 an increase was noted. On account of these conditions the control work done by the States and the cities and towns has been confined

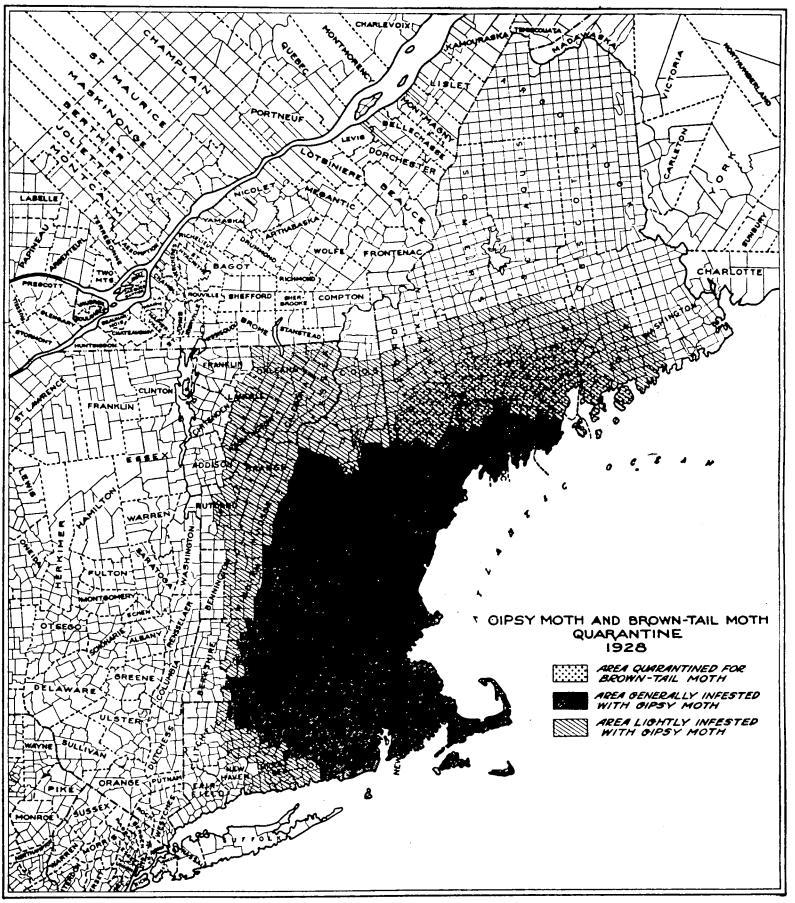

FIGURE 3.—Quarantined areas, 1928

chiefly to residential sections and to parks and street trees. Very little work has been done in woodland areas. More infestations were found in the barrier zone in 1928 after July 1 than during the entire previous fiscal year, which made the problem of preventing the increase of the insect far more difficult and emphasized the importance of carrying on work in the territory east of the zone in order to make it possible to keep the zone free from infestations. As a result of the increase in infestation directly east of the zone, 7 towns in Vermont, 12 in Massachusetts, and 31 in Connecticut, embracing an area of 1,581 square miles, were added to the generally infested area under quarantine.

During the latter half of 1929 and the first half of 1930 the number of infested locations continued to increase in the barrier zone and additional funds were made available by Congress to carry on clean-up work. No action was taken, however, to provide for the examination of territory immediately east of the zone from which most of these infestations originated and which furnish a source of constant supply of the insect so long as they remain untreated. The scouting work during the fall of 1929 and spring of 1930 resulted in the discovery of an increasing number of infested locations, although practically all of those found in previous years had been exterminated. Serious infestations were found in Branford, Middlefield, and Meriden, Conn., and Chester, Mass., towns immediately adjoining or close to the barrier zone line to the east. These colonies will be treated by the States concerned. Three of these colonies are in heavy woodland, and as no scouting work is done in woodland in most of the towns which border the barrier zone on the east, there is every probability that more infestations of this nature are present which, if allowed to remain untreated, will cause constant reinfestation of the areas that are being cleaned up.

Since the barrier zone was established, large areas immediately adjoining the zone on the west have been examined and two small infestations found and eradicated. Thus far the work in the barrier zone has accomplished its purpose, namely, the prevention of spread of the insect to the west and the extermination of the colonies as rapidly as they are located within the zone area.

RECORD OF CLEAN-UP OF OUTLYING GIPSY-MOTH COLONIES

In 1912 a small area was found heavily infested with the gipsy moth in Geneva, N. Y. Prompt action was taken by the State department of agriculture, and the Federal Bureau of Entomology cooperated. Clean-up measures were applied. Several very thorough annual examinations have been made but no trace of the insect has been discovered. In February, 1914, a colony was discovered at Bratenahl, a suburb of Cleveland, Ohio. Immediate attention was given this colony by the Bureau of Entomology in cooperation with the Ohio Department of Agriculture. As a result of thorough inspection and treatment work for three seasons, the colony was exterminated. In May, 1914, a colony was found by State inspectors in North Castle, Weschester County, N. Y. The infestation was heavy at the center and scouting determined that it extended over about 1 square mile. Intensive work was done throughout this area and the surroundings by the State and Federal forces, and although the locality was a very difficult one to treat thoroughly, the moth was exterminated. In the same year a small colony was exterminated at Rutherford N. J., by the Bureau of Entomology. In June, 1921, a small infestation was found at Greenport, near the east end of Long Island, N. Y., and during July another was reported at Patchogue on the south side of the island. The Bureau of Entomology, in cooperation with the State department of farms and markets, exterminated the insect in these colonies. Since that time several small infestations have been found on Long Island and have been exterminated by the New York State Department of Conservation. (Fig. 4.)

GIPSY-MOTH EXTERMINATION PROJECT IN NEW JERSEY

Early in July, 1920, the gipsy moth was found on a large estate near Somerville, N. J., by one of the State inspectors. The infestation centered in a large plantation of blue spruce trees, several acres of which were defoliated. Dead trees in the worst infested portion indicated that they had been killed as a result of defoliation and that the infestation was one of long standing. (Fig. 5.)

These trees had been imported from Holland about 10 years before, and there is no doubt that the infestation came with this shipment, which was received prior to the enactment of the plant quarantine act. This shows clearly the pressing need for precautionary measures to keep out dangerous pests.

Scouting work carried on during the fall of 1920 and spring of 1921, financed by the State of New Jersey and the Federal Government, revealed infestations of this insect in scattered localities in an area of over 400 square miles surrounding Somerville.

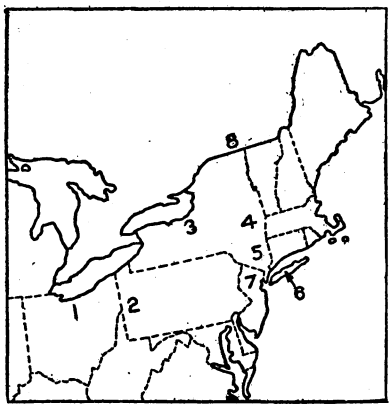

FIGURE 4.—Map showing locations, outside of the large New Jersey infestation and the barrier zone, where the gipsy moth has been exterminated: 1, Cleveland (Bratenahl), Ohio; 2, Loretto, Pa.; 3, Geneva, N. Y.; 4, Schenectady, N. Y.; 5, North Castle and Garrison, N. Y.; 6, Brooklyn, Roslyn, Kew Gardens, and Greenport, on Long Island, N. Y.; 7, Deal Beach, Wyckoff, South Orange, Scotch Plains, Paterson, Madison, Glen Rock, Elizabeth, and Rutherford, N. J.; 8, Henrysburg, Quebec, Canada

Previous successes in cleaning up local infestations led to the adoption of a cooperative plan to clean up this large, newly discovered infestation. State and Federal funds were appropriated, and the work was organized under the direction of the field office for gipsy moth control of the Bureau of Entomology. When the limits of infestation had been determined, the area was placed under State quarantine, which required, as a condition of movement from the infested area, certification as to freedom from infestation of all products likely to carry any stage of the gipsy moth. Thorough inspection which permitted certification was done in cooperation with the Federal Government and by Federal inspectors. The area under regulation has been gradually reduced as the results of the clean-up work have made this possible.

As soon as active work was under way in New Jersey it was discovered that trees had been shipped during the preceding years from the estate where the insect was first located and that the danger of the establishment of the insect in many localities was very great. Fortunately a record of all these shipments was available. It was found that 261 shipments had been sent to the District of Columbia and to 15 States outside of New Jersey as follows: Connecticut, Delaware, Florida, Illinois, Indiana, Kentucky, Maryland, Minnesota, Missouri, New York, North Carolina, Ohio, Pennsylvania, Virginia, and Wisconsin. These shipments were traced and inspections made of the planted stock by State or Federal officials. In

addition to this, 318 shipments had been distributed in New Jersey, and these were followed up in the same way.

As a result of this work small infestations were found at Loretto, Pa., Garrison, Roslyn, and Kew Gardens, N. Y., and Deal Beach, Wyckoff, South Orange, Scotch Plains, Paterson, Madison, Glen Rock, and Elizabeth, N. J. Thorough work cleaned up these small infestations during the following year, and repeated scouting has failed to indicate the presence of the pest.

In the meantime intensive work was carried on in the central part of the infested area, and more than 3,000,000 egg clusters were treated the first season. The trees on several acres were not only completely defoliated at the time the colony was discovered, but many were dead and others were in a dying condition. This intensive work pre-

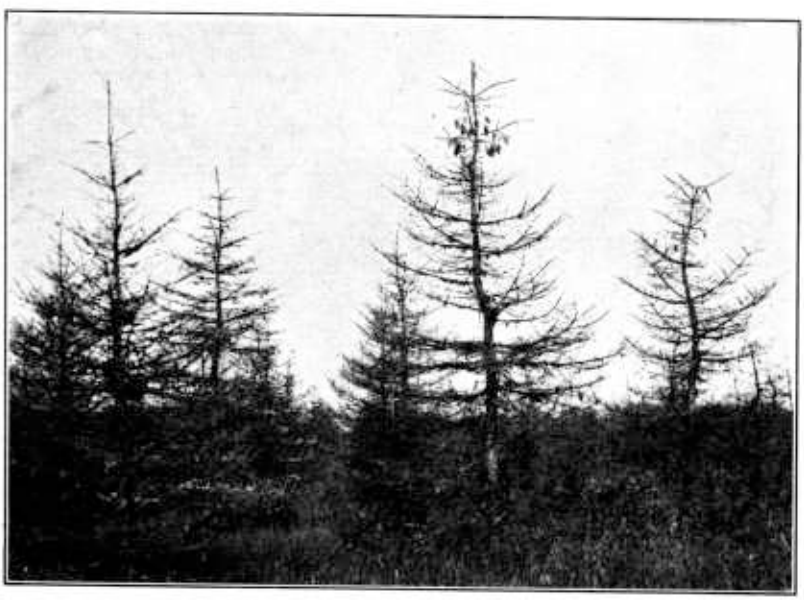

FIGURE 5.—Blue spruce defoliated and killed by the gipsy moth

vented defoliation the following season; in fact, no trees have suffered from gipsy-moth feeding in New Jersey since that time. During the next four years the scouting and clean-up operations were continued throughout the entire area known to be infested, particular attention being paid to a series of extensive woodland areas north of Somerville, known as the Watchung Ridges. These areas were by far the most difficult and expensive part of the territory to handle properly, as many square miles of woodland were involved. Substantial progress was made as the work proceeded. The density of the infestation in 1921 is indicated on the map in Figure 6.

Since 1925 continuous progress has been made in cleaning up and exterminating the gipsy moth in New Jersey. It has been necessary to operate in an area embracing 2,369 square miles, and the towns in the area where colonies have been found cover 924 square miles.

The area in which intensive scouting is necessary has been reduced to 197 square miles. (Fig. 7.)

LIFE HISTORY OF THE GIPSY MOTH

In the course of its life the gipsy moth passes through four stages—the egg, the larva or caterpillar, the pupa, and the adult or moth. (Fig. 8.)

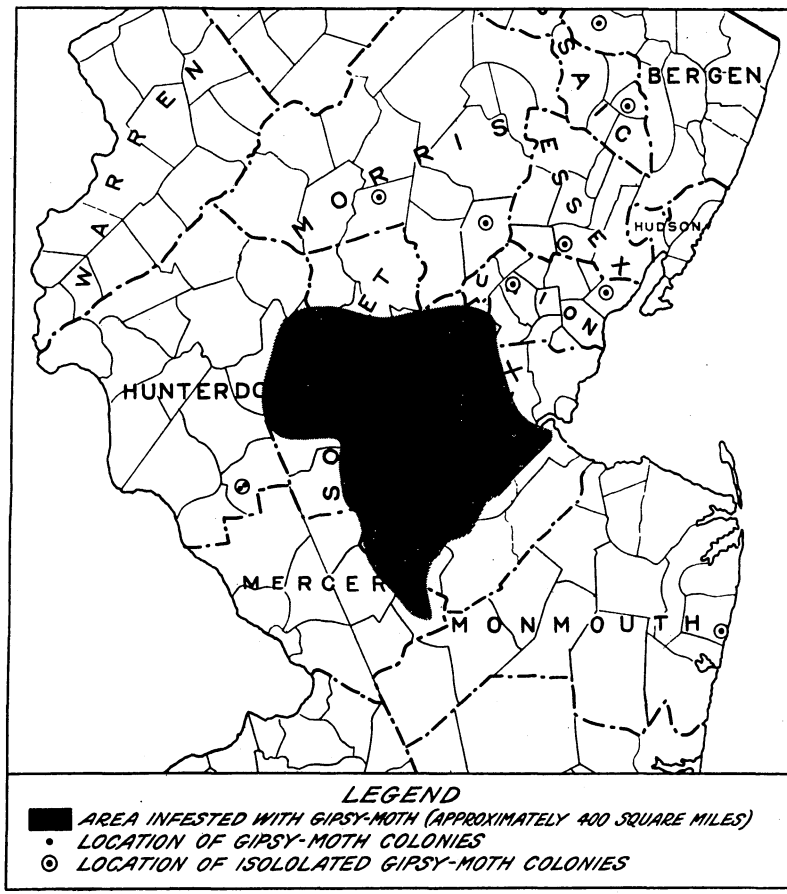

FIGURE 6.—Map showing area in New Jersey infested by the gipsy moth in 1921, indicating the density of infestation and location of isolated colonies

THE EGGS

The female gipsy moth deposits a cluster containing 400 eggs or more, which she covers with buff-colored hairs. Most of the egg clusters are laid during July and hatch about the time the leaves begin to appear the following spring. They are deposited on the under side of branches of trees, on tree trunks, under loose bark, or in cavities in the trunks or branches, and are sometimes placed on stones or rubbish and in a variety of situations where they are concealed from view. As the female moths do not fly, egg clusters are

seldom found far from the food plant upon which the caterpillars developed.

THE LARVAE

The newly hatched larvae feed on the opening leaves, making small perforations. They grow rapidly and become full fed early in July. During this period they molt five or six times, and as they increase in size they eat a larger proportion of the foliage, so that, if the infesta-

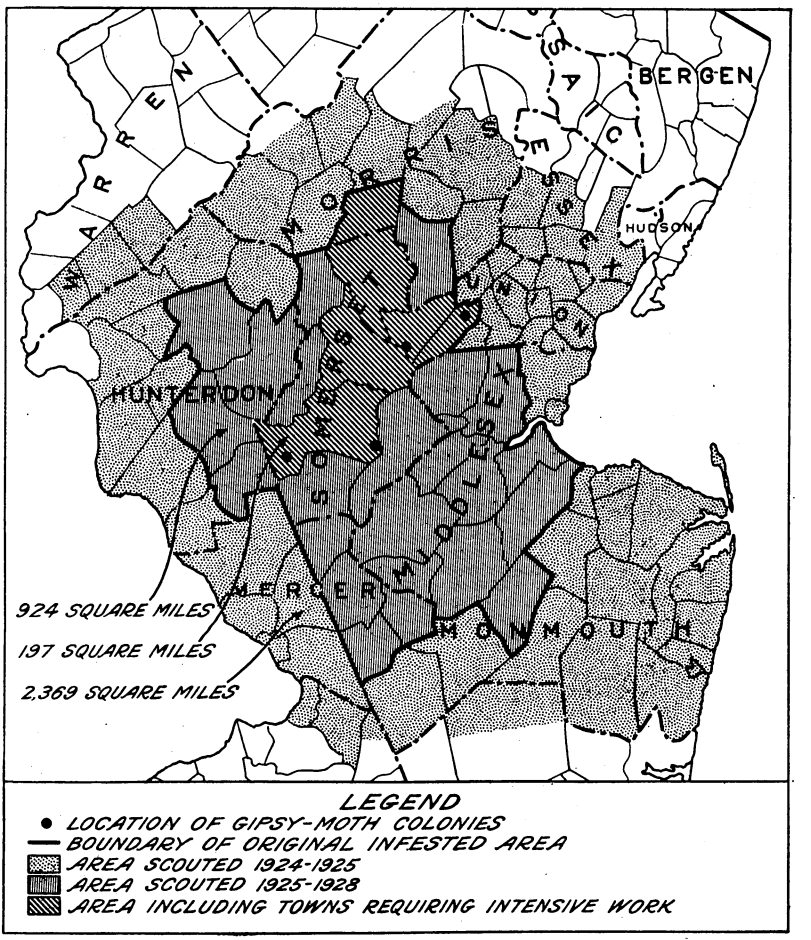

FIGURE 7.—Map showing conditions of infested area in New Jersey in 1928, indicating colonies and reduced area requiring intensive work

tion is severe, trees may be stripped completely of foliage before the end of June.

THE PUPAE

When full grown, the caterpillars shed their skins and transform to pupae, which are chestnut brown and provided with tufts of yellow hairs. They remain in this stage about 10 days, after which the adult insects emerge.

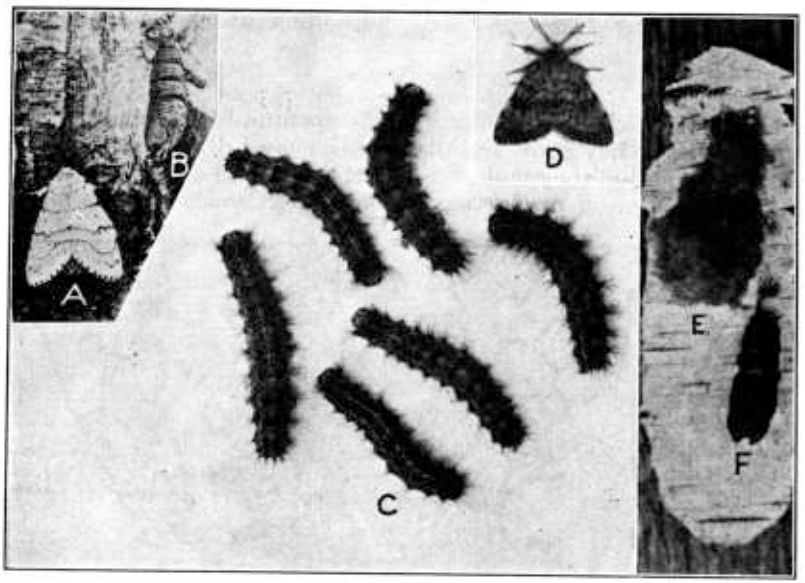

FIGURE 8.—Life stages of the gipsy moth: A, Female moth; B and F, pupae; C, larvae or caterpillars; D, male moth; E, egg mass. All about three-fourths natural size

THE ADULTS

The male moth is dark brown, with black wing markings, and flies well. The female is nearly white, with black markings on the wings, and because of the weight of the abdomen she does not fly. After mating, the females begin depositing eggs.

The time of year when the different forms of the insect may be found in the field is shown in Figure 9.

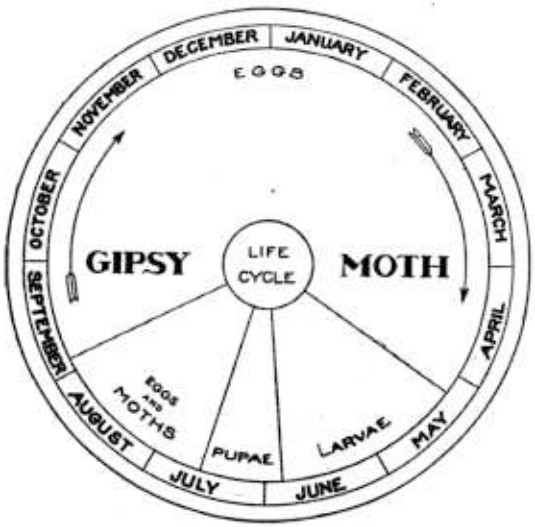

FIGURE 9.—Time of year when the different stages of the gipsy moth are present in the field

MEANS BY WHICH THE GIPSY MOTH IS SPREAD

Egg clusters of the gipsy moth deposited on trees, lumber, stone, or other products that are likely to be shipped, may be carried long distances and cause the establishment of new colonies of the insect. Spread in this way is prevented by inspection of such products before they are shipped. Caterpillars of this insect may be spread for limited dis-

tances by being carried on moving objects, such as trains, horse-drawn vehicles, or automobiles. The danger of such spread is very slight if the roadways are kept free from severe infestation. New colonies are started principally by the spread of newly hatched caterpillars. Experiments have shown that these caterpillars may be blown by the wind, if the temperature is high enough for the caterpillars to be active, and the stronger the wind the greater the probability of their being carried long distances. Caterpillars have been carried more than 20 miles in this way, and specimens have been caught in the air 50 feet above the ground, although probably they are carried much higher in the air. The temperature must range above 65° F. and the wind velocity must be 8 miles or more per hour, in order that spread of small caterpillars by wind may result.

In recent years a new avenue for spread of the gipsy moth has developed from the extensive use of the motor truck for long-distance hauling. Fortunately the material hauled is only occasionally of a dangerous nature, but chance of spread in this way is more or less constant.

The popularity of automobile camping parties presents another source of danger, particularly during the vacation season. There is a growing tendency, however, to restrict such camps to municipal or semipublic grounds. Under these conditions the danger can be minimized by proper inspection. Warning posters are being used in sections where parties are likely to camp, instructing them to examine their effects carefully so that no caterpillars or egg clusters of the insect will be carried away. Many camps in the heavily infested area are inspected annually.

FOOD PLANTS OF THE GIPSY MOTH

The food plants most favored by the gipsy moth are apple, the different species of oak, gray birch, alder, and willow. In cases of bad infestation nearly all deciduous trees are injured to a greater or less extent, with the exception of ash. Hickory is not a favored food plant, although the foliage occasionally shows severe feeding. Chestnut will not support the gipsy-moth caterpillars when in the first stage, and pine will not support them in the first two stages; but if other food plants are present severe injury may result from feeding by the larger caterpillars. Beech and poplar are sometimes fed upon freely, and occasionally the trees are defoliated. The different species of spruce are more susceptible to attack than the pines.

INJURY CAUSED BY THE GIPSY MOTH

Unless reduced in numbers by natural enemies, unfavorable climatic conditions, or the application of control measures, the gipsy moth is capable of causing enormous injury to tree growth. In the area of New England which has suffered most from this insect thousands of trees have been killed as a result of defoliation. (Fig. 10.) On many areas the trees were cut before they were mature and the wood sold at a loss on account of damage caused by the insect. Apple and oak have been injured most, but pine and other coniferous trees mixed with deciduous growth have suffered severely. (Fig. 11.)

FIGURE 10.—Deciduous trees defoliated by the gipsy moth

FIGURE 11.—White pine, in a mixed growth, defoliated by the gipsy moth

Many oak trees which have been weakened severely as a result of defoliation by the gipsy moth and the brown-tail moth have failed to recover because of the attacks of certain wood-boring insects. The species which has caused most damage in this way is a beetle (*Agrilus bilineatus* Weber) known as the two-lined chestnut borer, the larva of which feeds beneath the bark of injured trees.

EFFECT OF CLIMATIC CONDITIONS ON THE GIPSY MOTH

Investigations have shown that extremely low temperature during the winter is fatal to eggs of this insect that have been deposited in exposed situations. From −20° to −25° F. is usually required to injure them sufficiently to prevent hatching, and if the clusters are protected by snow, ice, or other material, the eggs are not killed even at this temperature. After extremely cold winters many eggs fail to hatch. Evidence also indicates that abnormally early frosts in the fall injure freshly deposited egg clusters.

During May, when the caterpillars are hatching, there are sometimes long periods of cold weather accompanied by heavy rains. This condition, or the occurrence of severe frosts in June, occasionally causes the death of the least hardy caterpillars.

NATIVE ENEMIES OF THE GIPSY MOTH

Few insect enemies of the gipsy moth native to New England cause any noticeable reduction in its numbers. This is shown by the fact that from 1900 to 1905, when no systematic effort was made to suppress the insect, alarming injury resulted, and native insect enemies did not increase to any marked degree. The same is true of the work of native insect-eating birds. While they undoubtedly feed to some extent on gipsy-moth caterpillars, there is no case on record where they have been able to control the insect. The "wilt," a disease which attacks and kills the caterpillars and pupae, has probably occurred in this country for many years. During some seasons, particularly in badly infested areas, it causes the death of an enormous number of the caterpillars and is often an important factor in reducing the infestation locally. As a rule, this disease is more common in heavy infestations, where overpopulation of caterpillars causes a scarcity of food.

INTRODUCED PARASITES AND ENEMIES

In 1905 an effort was made by the State of Massachusetts, in cooperation with the Bureau of Entomology, United States Department of Agriculture, to introduce the parasites and natural enemies of the gipsy moth from its native home in Europe and Japan. Since that time a large amount of parasitized material has been received nearly every year, and as a result some promising natural enemies have become established in this country and are assisting in bringing about the control of the species. The enemies which have become established and are at present destroying the largest number of gipsy-moth caterpillars and pupae are the Calosoma beetle (*Calosoma sycophanta* L.), two species of parasitic flies (*Sturmia scutellata* Desv. and *Compsilura concinnata* Meig.), one

of which attacks the brown-tail moth as well as caterpillars of many native insects, and two species of small wasplike flies (*Apanteles melanoscelus* Ratz. and *A. lacteicolor* Vier.), one of which likewise attacks the brown-tail moth. Two tiny parasites of the gipsy-moth eggs have also been introduced and colonized, one (*Oencyrtus kuvanae* How.) from Japan and the other (*Anastatus disparis* Ruschka) from Europe.

Several other parasites have been introduced and are established in this country; however, they have not increased sufficiently to be considered important factors in gipsy-moth control. Some additional parasites have been imported during the last three years, but their value has not yet been fully demonstrated.

The work of the natural enemies of the gipsy moth, including the imported parasites, the Calosoma beetle, and the wilt disease, has greatly reduced the numbers of the insect in many localities that are badly infested.

It is hoped that when the enemies of the moth are present in larger numbers over the entire infested territory the insect will become much less destructive than at present.

The records at the gipsy-moth laboratory at Melrose Highlands, Mass., indicate that the species of parasites introduced prior to 1923 increased gradually in the field until 1923, when they reached their greatest abundance, and the results of their work were very noticeable over much of the infested area.

In 1924 the gipsy moth was rather scarce, and parasitism was low; the following year it was still low and did not increase much in 1926. In 1925 the gipsy moth began to increase rapidly in the older infested area, and although some of the parasites gained slightly in 1927 and 1928 they did not prevent the rapid increase of the moth.

Until the natural enemies demonstrate greater effectiveness throughout the entire infested area it will be necessary to employ the best mechanical methods for restricting the spread and curtailing the increase of the gipsy moth. In the meantime further work is being done in foreign lands, particularly in central Europe and the Mediterranean countries, to determine the principal factors that are responsible for the periodical scarcity of the insect there and to take advantage of this knowledge for the purpose of developing more effective natural control in this country.

METHODS OF CONTROLLING THE GIPSY MOTH

GENERAL METHODS

Creosote.—One of the best methods of controlling the gipsy moth is to treat the egg clusters of the insect between August 1 and April 1 with creosote to which a small quantity of lampblack has been added. The material is sold by dealers in the infested region under the name of gipsy-moth creosote. It is applied with a brush and leaves a black residue on the clusters treated. Creosote may be obtained from nearly all the large hardware or seed stores in the infested district.

Burlap bands.—Gipsy-moth caterpillars usually seek shelter during hot, sunny days, and if a band of burlap is attached to a tree (fig. 12), large numbers of them will crawl beneath it, where they may

be crushed each day. Ordinarily a strip of burlap about 8 inches wide is placed loosely around a tree trunk and a piece of twine is passed around the center and tied to hold it in place. After this is done the top part of the burlap is folded down so that a double shelter is made beneath it. The extensive use of these bands has been discontinued during the last few years, owing to the expense

FIGURE 12.—Burlap band on tree with caterpillars beneath it

involved and because of the fact that if the burlap bands are applied early in the season, before the brown-tail moth caterpillars have pupated, an excellent place is furnished for these poisonous caterpillars to make their cocoons, and severe poisoning results to the workmen. If this method is to be used in areas where the brown-tail moth is abundant, the burlap should not be attached to the trees until after June 15, when most of the brown-tail moth caterpillars will have pupated.

FIGURE 13.—Caterpillars on tree trunk below sticky band

Sticky bands.—Bands of a widely known sticky substance for tree banding, which may be obtained on the market, may be used on tree trunks after the bark has been scraped so that the material can be applied evenly in a thin layer with a paddle. The purpose of this band is to prevent caterpillars from ascending the trees, and if the egg clusters have previously been treated, this is a very effective measure. Every week or 10 days during the caterpillar season a comb or other similar implement should be run over the band in order to prevent hardening of the surface and to bring up fresh, sticky material from the part of the band near the bark. (Fig. 13.) Placing these bands on the trees prevents the caterpillars from reaching the foliage; and as they usually mass in large numbers beneath the bands, conditions are favorable for wilt disease to develop, and the caterpillars often die in large numbers from this disease and from starvation.

Gipsy moth tree-banding material.[3]—This is a black, greasy substance which was prepared and tested by the Bureau of Entomology in cooperation with the Bureau of Chemistry. It is similar to the product known as "Raupenleim" that has been used in the German forests for many years to prevent injury to the trees by caterpillars. It is applied with a special "gun" designed for the purpose. (Fig. 14.) The thick, narrow band left on the tree trunk prevents the caterpillars from reaching the foliage. This material is cheap and effective and is easily applied because it is not necessary to scrape the trees before putting it on.

[3] For full information concerning the preparation and use of this tree-banding material, apply to the gipsy-moth laboratory of the U. S. Department of Agriculture at Melrose Highlands, Mass.

Spraying.—The most effective spray material for the gipsy moth is lead arsenate. It can be used either in the paste or powder form. More effective control is possible if a sticker is used in the spray. Fish oil or raw linseed oil is excellent for that purpose, as it binds the insecticide firmly to the foliage so that it is not removed by rain or heavy dew.

If either of these stickers is used the quantity of poison can be reduced from 12½ pounds to 10 pounds of paste lead arsenate or from 6¼ pounds to 5 pounds of powdered lead arsenate to each 100 gallons of water. Fish oil is cheaper than linseed oil and is therefore to be preferred. Four fluid ounces of the oil is required for each pound of poison used; in other words, 1¼ pints of oil for 5 pounds of powder or 10 pounds of paste.

In preparing the spray mixture, add the oil after the poison is well mixed with water in the tank and while the whole is being agitated. Continue the agitation while the spray is being applied. The best grade of fish oil, known as "light pressed," should be used, as the cheaper grades are not so satisfactory.

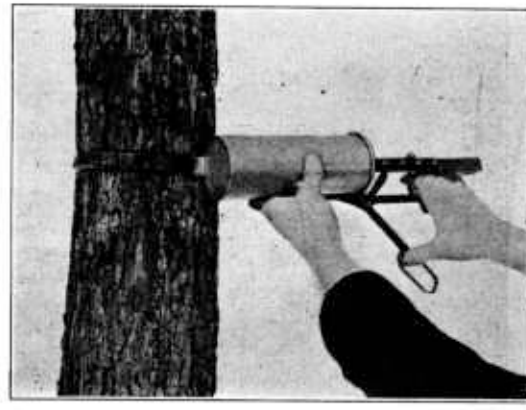

FIGURE 14.—Applying tree-banding material to protect the foliage from gipsy-moth caterpillars

Warning.—It is not safe to allow cattle to graze beneath trees after the spray has been applied. When there is danger of the spray drifting on buildings they should be drenched with water before and after the trees are treated. A garden hose can be used for this purpose. If the spray is allowed to dry, it will disfigure the painted surface. Spraying fruit trees with this mixture is not recommended if the fruit is more than half grown, as it is difficult to remove the spray residue.

For small operations the ordinary orchard sprayer may be used with one or more lines of hose, depending on the pressure that is available. Nozzles of the Vermorel or Bordeaux type are satisfactory.

In case large shade trees or valuable park or woodland trees are to be treated, the use of a high-power sprayer is more economical. The type that has given the most satisfactory results in the gipsy-moth work develops sufficient power to throw a solid stream of spray so it will drift through the trees. (See illustration on front cover.) The nozzle is constructed so that the stream will break into a fine mist high in the air, and this results in very satisfactory and rapid work. With such a sprayer it is unnecessary to use a small hose and climb trees, which is a slow and expensive operation.

A satisfactory high-power sprayer for this work is equipped with not less than a 10-horsepower gasoline engine and a triplex pump capable of delivering at least 35 gallons of liquid per minute at a

pressure of at least 300 pounds. This machinery, together with a 400-gallon tank, should be mounted on a well-built truck. (Fig. 15.) High-grade 1-inch spray hose is required, and a nozzle pressure of 300 pounds or more is necessary, depending on the length of the hose and the elevation of the nozzle above the level of the sprayer. Machines that will develop 1,000 pounds working pressure are necessary in rough country where extremely long lines of hose are required. A machine of this capacity equipped with high-pressure hose will supply a hose line 5,000 to 6,000 feet in length and spray satisfactorily at an elevation of 600 feet above the level of the sprayer.

By using a small device, which is attached to the nozzle and is known as a spreader, it is possible to spray low growth very satisfac-

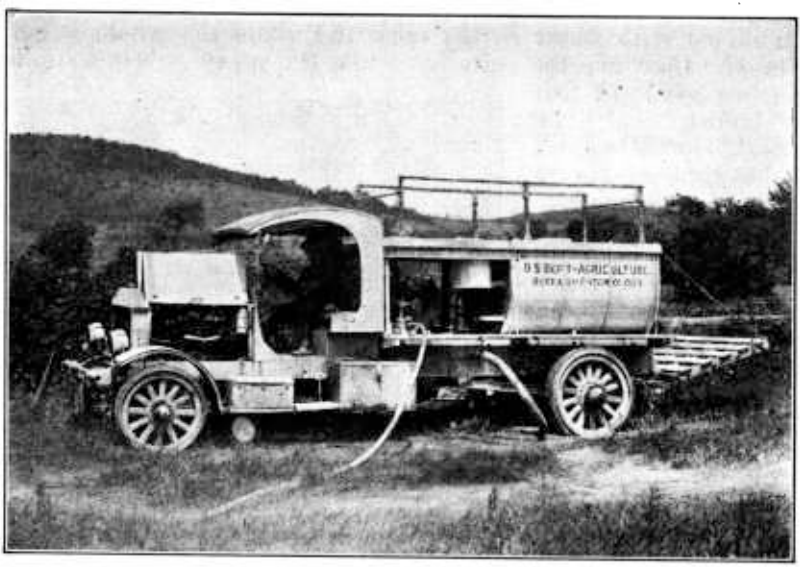

FIGURE 15.—High-power truck sprayer

torily. Fruit trees can be treated very rapidly in this way. (A nozzle equipped with spreader is shown in operation at the left of the picture on front cover.)

Tests have been made for several seasons with airships of both the heavier-than-air and lighter-than-air type, to determine whether infested woodland areas could be dusted satisfactorily and economically by these means. This method has not proved entirely satisfactory for use on forest growth. The cost is high, and the dust does not adhere as well as liquid spray when an adhesive like fish oil is used. For certain low-growing crops that have a high annual value this method has given excellent results in some sections of the country.

METHODS TO BE USED IN ORCHARDS

The methods to be used for controlling the gipsy moth in orchards depend largely on the severity of the infestation. If only a few egg clusters are present in the orchard, the early spraying which is

applied for the codling moth after the blossoms fall will be found useful, provided the quantity of lead arsenate used is increased to 10 pounds of paste, or 5 pounds of powder, to 100 gallons of water. This spray should be especially effective if fish oil is added. If the infestation is more serious, a second spraying early in June, with a similar quantity of poison, but without fish oil, will be found very satisfactory. Where the infestation is severe, it will probably be necessary to creosote egg clusters in the winter and spray in the spring. Thoroughness is a prime essential if good results are to be obtained. All poor or hollow trees should be removed; and if badly infested woodland is near by, the orchard trees should be banded.

Orchard infestations can be managed by following these methods, and it will not require much additional expense or a great deal of extra work to protect the trees. In making this statement it is assumed that the orchard is being cared for by up-to-date methods to protect it from the codling moth and other injurious insects and diseases, and it is not likely that these results can be brought about in neglected orchards or where the owners do not practice the best horticultural methods in handling their growing trees.

METHODS ADVISABLE IN CITIES AND TOWNS

The same methods that are used in orchards are applicable in cities and towns and for the treatment of park and shade trees. In certain instances it would probably be advisable to use tree-banding material or burlap, preferably the former, and to discontinue spraying in cases where the infestation is very light. If the infestation is bad, creosoting, banding, and spraying should all be used in their season, in order to bring the insect under control and reduce the numbers present to a minimum.

In town or city work careful attention should be given to near-by woodlands or isolated trees, particularly if they are located on high elevations immediately outside the residential area, as colonies in such locations may furnish a supply of caterpillars which will be distributed by wind throughout the town after it has been cleaned. In lightly infested woodland areas spraying may be used exclusively for control, but when heavy infestations exist, a combination of the most effective measures is usually necessary.

The method of handling the gipsy moth in any town, city, or park, or on private estates, should be based on the degree of infestation as determined by some one who is familiar with gipsy-moth work, if the best results are to be secured at a minimum expense. Much energy and money may be wasted in applying remedies unless their application is based on a thorough knowledge of exisiting conditions. An owner of an infested estate should have an examination made by some qualified person who can give reliable recommendations as to treatments. It should be borne in mind that conditions as to infestation vary from year to year, and this should be considered when plans for treatment are being made.

CONTROLLING THE GIPSY MOTH IN WOODLAND

Satisfactory control of the gipsy moth in woodland by the employment of hand methods such as have already been mentioned is im-

practicable under present conditions, unless the tree growth is particularly valued for purposes other than lumber. If the woodland is situated near a large city and occupies space that is likely to be utilized in a few years for building lots, considerable money may be expended to advantage in protecting the trees, as these will make the property much more valuable when the land is subdivided. Limited areas of woodland on private estates may be of sufficient value to the owners to justify a considerable expenditure for moth destruction. In all cases, however, the species of trees involved should be carefully studied before a plan of work is adopted, in order that the expense may be reduced as much as possible. Unfortunately the difficulty of treating the woodlands in the infested area of New England is considerably increased by the fact that they are for the most part composed of numerous species in mixture.

FIGURE 16.—Mixed deciduous and coniferous woodland before thinning

Experiments have shown that most coniferous trees are not injured by the gipsy moth if grown in isolated pure stands; and if the growth is such that the trees can be thinned to a stand of immune species, no hand suppressive measures are necessary in order to prevent injury by this insect. Such lots will not be attacked by the brown-tail moth, as the larvae of this insect do not feed on conifers.

If mixtures containing a large percentage of deciduous trees are to be protected from moth injury, the species involved should be carefully considered before a decision is reached as to the best methods of treatment. Sometimes practical methods of thinning (figs. 16 and 17) can be adopted so that species will be left that are only slightly subject to injury by these insects. Experiments have shown that mixtures of chestnut, pine, red maple, ash, and hickory, regardless of the proportion of each species, are seldom injured by the gipsy moth.

In woodlands the oaks are the most favored food plant of this insect, and, unfortunately, the infested region abounds in large areas where these species predominate. At present there seems to be no method aside from hand treatment which will prevent serious injury to oak woodland, but as a large part of such land consists of poor sprout growth, the amount of damage sustained is not always so great as it might at first appear. The greatest injury likely to be caused in such areas where oaks and gray birch abound is the dying of small pines or other valuable species which have been denuded by the caterpillars after the oaks and birches have been defoliated. This reduces greatly the chance that the sprout growth will be replaced by any species of value that can withstand gipsy-moth attack. Consideration is being given to devising some economical method for protecting and improving wood lots of this character at

FIGURE 17.—Same woodland after growth favored by the gipsy moth has been removed by thinning

moderate expense. It is true that in considerable areas of oak woodland the trees, although not mature, could be utilized for small timber, railroad ties, or cordwood, and in cases of bad infestation such woodland should be promptly cut if the wood can be sold to advantage. On cheap cut-over or infested lands in many sections of the territory white or red pine might be planted to advantage, but as this involves considerable expense and as the crop can not be harvested for a period of years, the question of the desirability of managing any wood lot in this way must, in the end, be decided by the owner of the property.

If the practice common in some European countries of maintaining municipal or state forests were well developed in the New England States, it would be possible in a period of years to transform considerable areas of land which are now destined to be worthless, and which form a favorable feeding ground for the gipsy moth, into well-managed forests of valuable growth.

THE BROWN-TAIL MOTH

INTRODUCTION AND SPREAD

The brown-tail moth (*Nygmia phaeorrhoea* Don.) was first found in the United States in Somerville, Mass., in the summer of 1897, and was undoubtedly introduced several seasons previous to that time on imported nursery stock. The insect increased enormously, and as the caterpillars were particularly fond of the foliage of fruit and ornamental trees and shrubs, they became an unbearable nuisance, particularly in residential sections. Not only was complete defoliation common in early summer, but as the hairs from the caterpillars caused serious poisoning to human beings, the presence of this pest became a veritable scourge in densely populated sections. The insect extended its range very rapidly because the moths of both sexes fly freely. This species occurs in many sections of Europe and is frequently seriously injurious.

The State of Massachusetts applied suppressive measures from the winter of 1897 until February, 1900, when this work was discontinued as was the case with that against the gipsy moth. By 1905, when work on the gipsy moth was resumed, the brown-tail moth was extremely abundant in eastern Massachusetts. It was also present in enormous numbers in Rhode Island, southern New Hampshire, and southeastern Maine. Not only did fruit and shade trees suffer defoliation, but large areas of oak woodland, particularly sprout growth, was completely defoliated.

The insect continued to spread until 1915, when most of the area east of the Connecticut River, with the exception of a portion of northern New Hampshire and Maine, was heavily infested. Some infestation also existed in Vermont and west of the Connecticut River in Massachusetts and Connecticut. Suppressive work was carried on by the States and the Federal Government and the residential sections were kept fairly free from this pest.

The area now infested by the brown-tail moth is shown in Figure 3, and is much less extensive than the maximum limits to which it had previously spread. Unfavorable winter conditions, particularly in the northern part of the territory, coupled with the work of natural enemies and disease and the continuous repressive measures used in the residential sections, have caused a remarkable decrease in the abundance of this pest. The insect has been found in Nova Scotia and New Brunswick, but the area of the infested territory has been greatly reduced there and it is only moderately abundant at the present time in sections of Nova Scotia.

This pest can easily be shipped on woody plants, but general spread in this manner has been prevented by the strict enforcement of inspection and quarantine regulations.

LIFE HISTORY OF THE BROWN-TAIL MOTH

The different stages in the development of the brown-tail moth are shown in Figure 18.

THE EGGS

The female moth deposits a small cluster of eggs on the underside of a leaf. They are usually laid in July, and are covered with brown

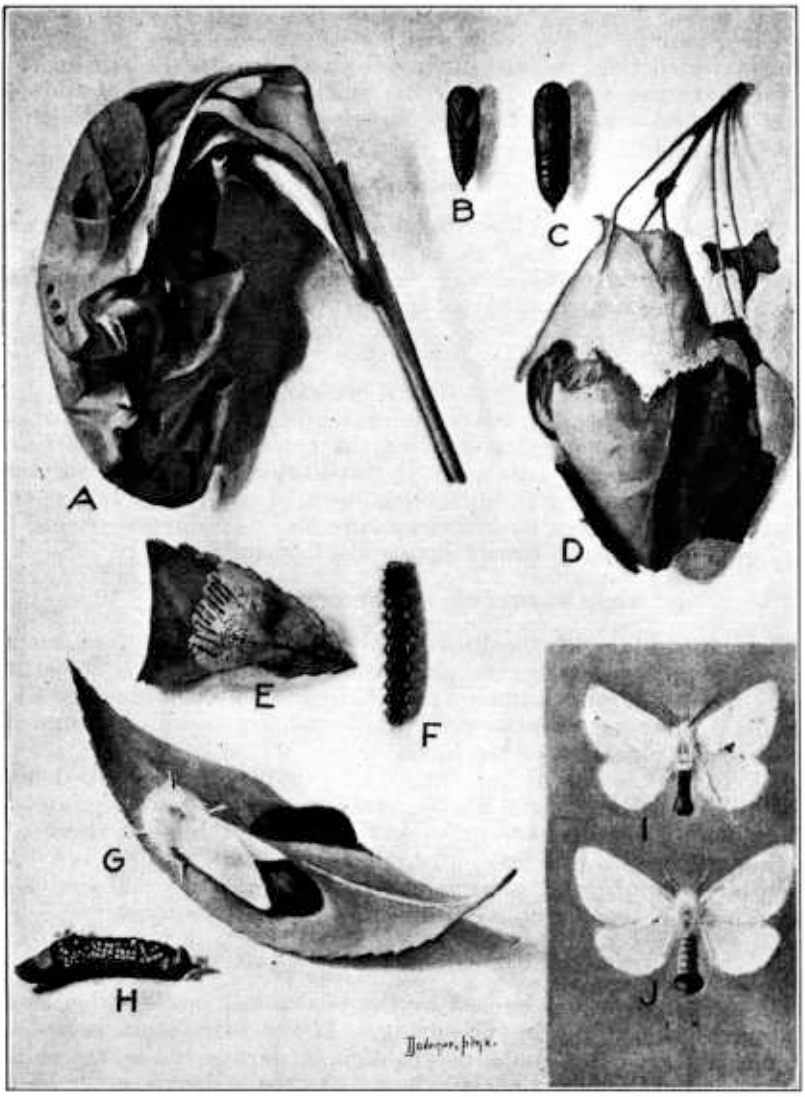

FIGURE 18.—Different stages of the brown-tail moth: A, Winter nest; B, male pupa; C, female pupa; D, cocoon in leaves; E, young caterpillars on leaf; F, full-grown caterpillar; G, female depositing eggs on a leaf, and egg mass also on leaf; H, egg mass removed from leaf and with some of the eggs exposed; I, male moth; J, female moth. All about three-fourths natural size

hair taken from the body of the female. Hatching begins about August 15.

THE LARVAE

The newly hatched larvae or caterpillars feed on the epidermis of the leaf. After molting once or twice they begin to construct a winter web. This is made by drawing together several terminal leaves and securely fastening them by silk which is secreted by the

caterpillars. The larvae from one or more egg clusters live and feed in common, and as cold weather approaches they retire to the web, in which they remain during the winter. In the spring these larvae leave the web as soon as the buds begin to develop and feed upon the bud scales and small leaflets. They become full grown about the middle of June.

THE PUPAE

After the caterpillars finish feeding they spin loose silken cocoons and pupate within them. These cocoons are sometimes constructed separately, but in many cases large numbers of them are spun in a single mass. About two weeks are spent in the pupal stage.

THE ADULTS

Emergence of the moth usually begins the first week in July. The adult brown-tail moth is pure white. The abdomen of the female is much larger than that of the male, but in both sexes the tip of the abdomen is covered with dark-brown hairs. These moths are attracted to strong light, such as electric arc lights; and as they fly at night, it is often possible to secure many specimens around the arc lights in cities and towns during the first half of July.

FOOD PLANTS OF THE BROWN-TAIL MOTH

The caterpillars of the brown-tail moth commonly feed on the leaves of apple, pear, cherry, oak, and willow, and they are sometimes found in considerable numbers on other common deciduous trees and shrubs. They never attack conifers and are seldom found on hickory, ash, chestnut, or birch.

Oak foliage is one of the favored foods of the brown-tail moth caterpillars in Europe and was severely injured in New England for a number of years after this insect became established there. It has not suffered in this way in recent years except in 1926 and 1927, when large numbers of webs were found on oak trees and the caterpillars caused considerable defoliation in some localities.

INJURY CAUSED BY THE BROWN-TAIL MOTH

The principal injury caused by the brown-tail moth is due to the feeding of the larvae in the spring. If the infestation is bad the caterpillars are often numerous enough to devour the leaves as fast as the trees are able to develop them. As the webs are made on the terminals, the growth of the trees is often severely checked. In severe infestations trees may be completely stripped (fig. 19), but as the larvae become full grown during the first part of June, there is usually an opportunity for the trees to produce new leaves before midsummer. The young larvae that hatch in August frequently skeletonize the leaves to a considerable extent. This does not damage the trees seriously, as the growing period for the season is nearly completed.

The bodies of the caterpillars of the brown-tail moth are provided with poisonous hairs. A microscopic examination of these hairs shows that the edges are barbed in such a way that when they come in contact with the human skin and are pressed into the flesh, intense

irritation is caused. These hairs are hollow and contain a poisonous substance which acts on the blood corpuscles. This causes serious poisoning and severe irritation, accompanied by external swelling, which is known as the brown-tail rash. Persons differ considerably in their susceptibility to this poison, but many cases are reported each year in the infested region, most of which are more serious than those of ivy poisoning. Many camps and summer cottages, particularly in wooded areas, can not be occupied with any comfort during the early summer if the caterpillars are abundant, on account of the poisoning due to these caterpillars. If clothing is hung on the line near badly infested trees the hairs frequently find lodgment and are brought into the houses, and severe poisoning may result later.

FIGURE 19.—Apple trees defoliated by the brown-tail moth. Note the hibernating webs on the twigs

The brown-tail moth has been less abundant during the last three years than heretofore. There have been local infestations, however, where serious injury resulted, particularly in northeastern Massachusetts, southeastern New Hampshire, and southwestern Maine, and in some of the river valleys in New Hampshire.

NATIVE ENEMIES OF THE BROWN-TAIL MOTH

One of the important native enemies of the brown-tail moth is a fungous disease (*Entomophthora aulicae* Reich.) which attacks the caterpillars, particularly in the spring. It was first reported in this country by Roland Thaxter in 1888. Like all diseases of this nature, the benefit derived from it is regulated largely by favorable or unfavorable weather conditions. This fungus sometimes works to a slight degree on the small caterpillars in the fall, and is found occasionally in the winter webs. As a rule, however, the greatest

mortality of caterpillars takes place in the spring, when they are nearly full grown, and the pupae may, under the most favorable conditions, be almost completely exterminated.

Native parasites and predacious insects have done very little to check the increase of the brown-tail moth.

INTRODUCED PARASITES AND ENEMIES

Some of the parasites (*Apanteles lacteicolor* Vier. and *Compsilura concinnata* Meig.) that were introduced as enemies of the gipsy-moth caterpillars also attack those of the brown-tail moth freely, and one additional introduced species (*Meteorus versicolor* Wesm.) is an important enemy of the insect. The Calosoma beetle (*Calosoma sycophanta* L.), both in the adult and larval stages, destroys many brown-tail moth larvae and pupae.

The parasites and natural enemies of this insect are more effective than is the case with the gipsy moth, and extremely low temperature in the winter often proves fatal to a large proportion of the small caterpillars in the webs.

These factors, together with the enormous amount of hand suppression that has been employed in many parts of the infested area, have resulted in a pronounced decrease in the abundance of the insect during the last few years.

METHODS OF CONTROLLING THE BROWN-TAIL MOTH

The brown-tail moth can be controlled by cutting off the winter webs and burning them before the caterpillars begin to emerge in April. These webs should be destroyed by fire, for if they are simply cut from the trees and left on the ground, the caterpillars will emerge, and no benefit will result from the work which has been done.

In orchard practice it is sometimes inadvisable to cut the winter webs, for where an infestation is bad the cutting is likely to leave poorly shaped trees. Spraying in the spring is not a satisfactory remedy unless the infestation is very light, because the caterpillars, when they occur in large numbers, do not allow the tree to put out sufficient foliage to hold the spray material.

The most effective method in orchards is to spray the trees before the midde of August, using 3 pounds of lead-arsenate powder to 100 gallons of water. Before spraying operations of this sort are attempted the orchardist should determine to what extent the trees are infested with egg masses of the brown-tail moth. If the infestation is very slight, it will be more satisfactory to cut and destroy the webs. If the infestation warrants, both shade, ornamental, and fruit trees may be sprayed to advantage at this time. Caution should be used, however, in spraying fruit trees, particularly if early-fall varieties are to be treated. The foliage should be treated, particularly the terminal shoots, and as much care as possible should be exercised not to cover the fruit. Late fall or winter varieties of fruit may be sprayed with lead arsenate in August, and although an occasional spot may be found on the fruit at the time of picking, no injury will result from it. In cases where only a few choice fruit trees are sprayed it is practicable to wipe the fruit before packing for sale;

but this will not be necessary if care is taken to spray only the terminal growth of the trees, as this is where the bulk of the egg clusters are deposited.

The damage caused by the brown-tail moth is ordinarily not so severe as that resulting from gipsy-moth infestation, because the brown-tail moth does not have so wide a range of food plants and, further, because the bulk of the feeding by the larvae is done early in the season, so that the trees have an opportunity to recover before midsummer. In the territory where both insects exist the caterpillars of the gipsy moth supplement the feeding which has been done by those of the brown-tail moth, and the injury is, therefore, greatly increased.

During the last few years this insect has seldom been found feeding on oak foliage, except in the worst infested localities, and elm, maple, and rose are not as badly infested as was the case about 15 years ago.

Thorough destruction of brown-tail moth webs in residential sections and in orchards has resulted in materially decreasing the insect in thickly settled sections. Elimination of worthless apple and wild cherry trees would help greatly in reducing the pest.

ORGANIZATION AND STATUS OF WORK AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH

Each State infested with these insects is carrying on control work, and many of the towns and cities are similarly engaged.

The Dominion of Canada and several of the Provinces have taken up control and eradication work.

MAINE

In Maine the work is in charge of the commissioner of agriculture, who has authority to appoint assistants to take charge of the operations. In the southwestern part of the State the gipsy-moth infestation is general and in places severe, but the greater part of the known infested area is only slightly infested. The severity of infestation increased in 1926 and 1927, and many heavily infested sections were found in 1928. The brown-tail moth is not now seriously abundant except along the seacoast in the southwestern part of the State. Over 12,000 square miles of territory are infested with the gipsy moth and about 7,000 with the brown-tail moth. The former has gradually spread to new territory, but the area infested by the latter has decreased considerably since 1919 and has not changed very greatly for several years.

NEW HAMPSHIRE

The moth work in New Hampshire is in charge of the State entomologist. Over 8,000 square miles are infested with the gipsy moth and about 4,000 with the brown-tail moth. Most of the territory south of Lake Winnepesaukee has suffered severe and repeated defoliation. In 1927 the largest defoliated areas centered around the lake and toward the east and northeast. In 1928 severe defoliation was general throughout the section east of the Merrimac River and to the foothills of the White Mountains. Serious stripping also occurred west of the river in the southern part of the State.

VERMONT

In Vermont the moth work is in charge of the commissioner of agriculture, who appoints an entomologist to carry on the field work. About 6,000 square miles are infested by the gipsy moth, the worst localities being along the Connecticut River. An occasional web of the brown-tail moth has been reported in recent years, but this insect does not appear to maintain itself in numbers in the State.

MASSACHUSETTS

The commissioner of conservation has charge of the moth work in Massachusetts. Each infested town is required by law to select a local superintendent, whose appointment must be approved by the commissioner. Owners are required by law to keep their property free from these pests, but can not be compelled to expend for this purpose more than $5 per year on each $1,000 assessed valuation. Towns and cities must expend funds for proper treatment of the street trees and those in parks and on public grounds. After the amounts fixed by law are expended, financial aid may be supplied by the State. The gipsy moth at present occurs to a greater or less extent in every town in the State east of Berkshire County. It has increased in abundance over much of the infested area during the last three years. The area infested by the brown-tail moth has been reduced so that at present it amounts to only a little over 4,000 square miles.

RHODE ISLAND

In Rhode Island the commissioner of agriculture has charge of the moth work, which is done under the supervision of the State entomologist. The gipsy moth occurs in all towns in the State, and several heavy infestations were treated during 1927 and 1928. The brown-tail moth infestation has decreased rapidly in recent years, and at present none of the towns are known to be infested.

CONNECTICUT

In Connecticut the work is in charge of the State entomologist. The brown-tail moth has not been found in this State for several years. The gipsy-moth area now occupies about 3,000 square miles. Control work has heretofore been effective in controlling the insect, but during the past two years the infestation has been increasing somewhat in the eastern part of the State.

NEW YORK

In New York State the field work against the small number of scattered colonies that had been found up to March, 1923, was supervised by the director of the bureau of plant industry, of the department of farms and markets. At that time the work was transferred to the department of conservation, which has worked cooperatively with the Bureau of Entomology in the New York section of the barrier zone.

NEW JERSEY

In New Jersey the State work is under the control of the State department of agriculture. The funds appropriated have been used in conjunction with Federal funds, and the direct supervision of the work has been in the hands of the United States Bureau of

Entomology. The results, up to the present time, have been very satisfactory.

PENNSYLVANIA AND OHIO

Work on one small colony in Pennsylvania and another in Ohio was done by arrangement with the State officials—in Pennsylvania with the bureau of plant industry of the department of agriculture of that State and in Ohio with the State nursery inspector. The results were satisfactory, as both colonies of the insects have been exterminated.

WORK OF THE DOMINION OF CANADA

Work on the gipsy moth and the brown-tail moth in Canada is conducted by the division of foreign pests suppression of the office of the Government entomologist. Cooperation with the Provincial governments of New Brunswick, Nova Scotia, and Quebec has been maintained. The brown-tail moth is not now known to occur in the Province of New Brunswick but is found in decreasing numbers in the Annapolis Valley in Nova Scotia. The gipsy-moth colony found at Henrysburg, Quebec, has been exterminated through the efforts of the Dominion and Provincial officials, and the insect is not known to occur in Canada at the present time.

WORK OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

The gipsy-moth project has for many years been conducted by the Bureau of Entomology. On July 1, 1928, the quarantine and control work was transferred to the Plant Quarantine and Control Administration, and the research work was assigned to the Division of Forest Insects of the Bureau of Entomology.

The object is to control and prevent the spread of these insects. For a number of years it was believed to be quite impossible to restrict the spread of the brown-tail moth on account of the heavy migration of the adults of this species. In recent years, owing principally to the effectiveness of parasites introduced by the bureau, winter conditions unfavorable to the insect, and in some sections the effectiveness of a fungous disease which attacks the caterpillars, in addition to a large amount of hand suppression work, it has been possible not only to prevent spread but to record a marked reduction in the infested area. In certain sections near the seacoast in New Hampshire and northern Massachusetts and near some of the rivers, however, rather heavy infestations exist. One of the dangers in connection with the brown-tail moth at present is that favorable climatic conditions or temporary scarcity of natural enemies may enable it to increase rapidly and spread proportionately.

The gipsy moth was held in check for several years and did not spread beyond the Connecticut River. During the war period, when extreme difficulty was experienced in maintaining a field force on an effective basis, and funds were inadequate to meet the increased cost of operation, infestations developed rapidly, and strong winds immediately following the hatching period caused an extensive spread of the insect to the west and northwest. Field work indicated that many colonies were established during that period, as scattered infestations were found in the Berkshire Hills section of Massachusetts and Connecticut and in the Green Mountain region in Vermont.

This territory is extremely rugged and very difficult for field operations.

The establishment of the barrier zone has already been discussed in some detail, and the results secured thus far have justified the effort expended.

A large amount of experimental work has been done to devise better methods of controlling these insects. Natural enemies have been introduced from Europe, northern Africa, and Japan and colonized throughout most of the infested area. Specialists have spent considerable time studying the insects in their native homes and collecting parasites for shipment to this country. This phase of the work is being pressed as rapidly as possible. Investigations looking toward the planting and growing of forest trees that are not subject to attack by the gipsy moth are being continued.

The entire area known to be infested by either of these insects is under quarantine, and shipments of nursery stock, lumber, cordwood, and other forest products, including Christmas trees and greenery, and stone and quarry products are not permitted to leave the territory unless they are inspected and accompanied by a certificate stating that they are free from infestation.

COOPERATIVE WORK

Since the gipsy moth and brown-tail moth work was begun by the Bureau of Entomology more or less work has been done in cooperation with the States concerned. The introduction of parasites and natural enemies of the gipsy moth was conducted in cooperation with the State of Massachusetts for several years. After the infestation had covered large areas in other States an arrangement was made for this work to be carried on by the Bureau of Entomology. The general plan of field work in New England is for the States to manage the clean-up east of the barrier zone while the Federal forces work in the zone and cooperate in making the entire work effective.

In New York the barrier zone work is handled in cooperation with the State authorities.

The work in New Jersey is planned with the purpose of exterminating this large infestation, and close cooperation with the State has been maintained.

The gipsy moth and brown-tail moth quarantine covers the entire infested area, and its enforcement has thus far prevented long-distance spread of these pests.

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